Volume 24
Number 280 *Effect of Hormodin A, a growth substance, on the rooting of cuttings*
Article 1

October 1940

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October, 1940 Research Bulletin 280

Effect of Hormodin A, a Growth Substance, on the Rooting of Cuttings

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Effect of Hormodin A, a Growth Substance, on the Rooting of Cuttings[1]

By Marcus A. Maxon, B. S. Pickett and H. W. Richey

Florists, nurserymen and gardeners are deeply interested in recent discoveries that certain chemical compounds, when absorbed into the appropriate living plant tissues, induce or stimulate the initiation of roots. Depending on species, point of application of the chemical and various environmental conditions, roots appear on stems or leaves at points where roots do not ordinarily arise. The chemicals used have been variously designated by different investigators as growth substances (6), hormones (3), phytohormones (28) and auxins (28). When applied to the rootage of cuttings, these substances may have a wide practical use.

Some of the most effective growth substances are offered to the trade under proprietary names. This bulletin deals with a series of experiments designed to test, under Iowa conditions, the efficacy of Hormodin A, a widely distributed trade product known to contain an effective growth-promoting chemical, indolebutyric acid, for the rooting of cuttings of many species and varieties of horticultural plants. The project was sponsored by the Boyce Thompson Institute for Plant Research, located at Yonkers, N. Y., under a cooperative agreement with the Iowa Agricultural Experiment Station. The study covered a period of 2 years and included tests with approximately 50 species and varieties. The immediate objectives of the research were: 1. To discover the most effective concentration of Hormodin A for the rooting of each species or variety; 2. to determine the effect of the treatment on cuttings taken at different stages of maturity; 3. to determine the reaction of cuttings taken at different seasons of the year to the treatments.

Research workers are generally agreed that, 1. indolebutyric acid is more effective than indoleacetic, indolepropionic or naphthaleneacetic acids in rooting cuttings; 2. growth substances are effective in extremely minute quantities, but within sharp limits; high concentrations kill the base of the cutting, cause excessive proliferation of cells, cause callusing and check further growth of roots and shoots; concentrations below optimum are ineffective; 3. the duration of the time of treatment is

[1]Project 586 of the Iowa Agricultural Experiment Station.

closely correlated with the concentration of the solution used; within limits a high concentration may be used for a short period of time or a lower concentration for a longer period with comparable results (6, 11); 4. treatment accelerates the rooting of cuttings, produces a larger root system, increases the percentage of rooting and makes it possible to root cuttings of some species that normally root poorly, or not at all; 5. if neither speedy rooting nor rapid growth of roots in the cutting stage is important in the propagation of a particular species, there may be no economic advantage to the propagator in using growth-promoting chemicals; Skinner (17), for example, calls attention to the fact that most reported data are incomplete because of failure to allow for the effect of time on the rooting of untreated cuttings; these cuttings, if left in the rooting medium long enough, may ultimately root and give as high a percentage of rooting as treated cuttings; 6. comparatively few species which root with extreme difficulty under ordinary propagating conditions are benefited by treatment; inherent factors other than those affected by growth substances are involved (19).

Although the hormone theory of root production in cuttings was advanced by Sachs in 1880 (16) and substantiated by Van der Lek (22) in 1925, there was little save inferential evidence to support their hypotheses until Went (27) reported in 1929 that a substance of unknown composition and character, and present only in very small amounts, extracted from certain plant tissues, exerted a marked stimulus on the root production of cuttings. Further work in Holland and Germany revealed that substances obtained from a variety of plant tissues, as well as from human urine, were effective in stimulating root formation. Three substances were isolated, physiologically indistinguishable from the natural growth substances, which were named auxin a, auxin b and heteroauxin (indoleacetic acid). Studies were immediately undertaken in Europe to determine the effectiveness of indoleacetic acid for the rooting of cuttings of horticultural plants. Among the experimenters making these tests were Fischnich (4), Laibach (13), Tincker (20) and Van der Lek and Krijthe (23). In America, in 1936, Hitchcock and Zimmerman (6) found that several synthetic organic acids, especially indolebutyric and naphthaleneacetic, were more effective than indoleacetic acid in stimulating rootings of cuttings.

Three methods of introducing the growth substance into the living cells of the cuttings, where it must arrive to be effective, have been used. The first was to mix the substance with lanolin and smear the mixture over the base of the cutting or the part from which it was hoped that roots would grow. The second, introduced by Hitchcock and Zimmerman (6, 7) was to immerse the base of the cutting in a solution of the growth substance and rely on absorption and the movement of the transpiration stream to make it effective. The third method, first reported in 1937 by Grace (5), consisted of dipping the ends of the cuttings into a fine talc powder with which a growth substance had been mixed. Further work with powders has been done by Stoutemyer (18). The success of the lanolin and dust methods depends on direct absorption of the growth substance by the cells immediately in contact with the material or on enough being dissolved in the soil moisture so that it will ultimately reach the points of root initiation in the transpiration stream.

Neither the lanolin nor the dust methods permit precise control of concentrations nor quantities of growth substance entering the cuttings, and the former is not adapted to horticultural practice because of its inconvenience. The solution method, although less convenient than the dust method, is, nevertheless, simple enough for practical use and is comparatively exact in its control of concentration and absorption into the cutting. The technique of using the solution method needs to be standardized for local conditions, the work of several investigators, Brase (1), Chadwick (2), Hitchcock and Zimmerman (7), Oliver (14), Pearse (15), Thimann and Delisle (19), Tincker (20, 21), Van der Lek and Krijthe (23) and Yerkes (29), disagreeing on certain details.

THE EXPERIMENTS

Herbaceous, greenwood, evergreen and hardwood cuttings from many species[2] of plants growing in the college greenhouses or on the campus and horticultural farm were employed in the tests. The cuttings were made monthly from October to May in the case of evergreens, as frequently as material permitted in plants propagated by herbaceous and greenwood cuttings and during the winter with hardwoods. Herbaceous and greenwood cuttings were generally selected from the tips of vigorously growing shoots and were prepared in the regular commercial manner, except that as much foliage as possible was left above the ground line. In a few very foliaceous plants the leaves themselves were trimmed back. Side branches near the base of evergreen cuttings were cut away smoothly to prevent rotting, but needles alone caused no difficulty and were not similarly removed. Within limits large cuttings were preferred to small ones. Hardwood cuttings were taken while dormant, cut 12 to 18 inches long and stored in moist sphagnum moss at a tem-

[2]The nomenclature used in this publication follows Standardized Plant Names, except in case of direct quotation from a reference. This authority is used because of its general accuracy and its widespread acceptance in American horticulture.

perature which ranged between 40° and 50°F., until callus had formed.

Incident to the tests, modifications of technique were introduced in special cases. At the beginning of the experiments, two media were used; the first, a fine-screened plasterer's sand with a water-holding capacity of 27 percent, and the second, a mixture of three parts of this sand and one part of German peat, with a water-holding capacity of 34 percent. These media "waterlogged" and were later replaced with corresponding media made up with a coarse river sand having a water-holding capacity of 24 percent. A mixture of this sand with peat proved no better than the previous peat and fine sand mixture; and the coarse sand alone, having given the best results during the first year's experiments, was used generally as a medium thereafter. Drainage of the media was improved by spacing the bench boards 2 inches apart and laying ¼-inch wire screen over the cracks, this in turn overlaid with enough coarse gravel to prevent the sand from running through. Cypress flats set in the bench were also used freely for *Thuja, Taxus* and *Chamaecyparis,* which were found to root better than most of the other species in a medium holding more moisture. The flats, 5 inches deep, provided with several half-inch holes in the bottom for drainage, filled 2 inches deep with coarse gravel and then filled to the top with coarse sand, were found to retain a higher percentage of moisture for longer periods than the open benches.

GROWTH SUBSTANCE (HORMODIN A)

Hormodin A, a solution of indolebutyric acid dissolved in ethyl alcohol, used throughout the investigation, is the trade name of a compound manufactured by Merck and Company, Rahway, N. J. The manufacturers give specific directions for preparing various dilutions by the addition of water to the stock solution. To simplify its use by non-technical workers, the strength of the stock solution and of the dilutions is expressed by an arbitrary standard—the B. T. I. unit, 1 milligram of indolebutyric acid per liter of water, or 1 part per million.

Herbaceous cuttings were usually tested within the ranges of 20, 10, 5 and 2.5 B. T. I. units; greenwood cuttings fell within the same range but were treated with 40 units as well. The range for evergreens included 80, 40, 20 and 10 B. T. I. units. Hardwood cuttings were unresponsive except at still higher concentrations, usually 160 and 80, but 40 and 20 units were also included in the tests. The 160-unit material was specially prepared by Merck and Co. in order to avoid the toxic effect of the high concentration of alcohol incident to the use of the regular Hormodin A solution.

TREATMENT OF CUTTINGS

The treatment of the cuttings described by Watkins (25, 26) and Kirkpatrick (9, 10, 11, 12), of the Boyce Thompson Institute, was followed. The cuttings were sorted into uniform lots of 10 each, bound with rubber bands and placed in 150-milliliter beakers containing about 50 to 80 milliliters of solution, immersed to the depth of an inch or two, depending on the bulk of the cuttings. The beakers were placed on a laboratory bench protected from direct sunlight. Any glass or enameled vessel of suitable size and depth makes a satisfactory container. As the temperature of the laboratory was variable, and the humidity low, it was necessary to syringe the cuttings frequently to prevent wilting. Usually a piece of cheesecloth was thrown over them as an additional protection.

The customary practice of leaving the cuttings in the solution for 24 hours was followed throughout the investigation. At the end of this time the cuttings were removed from the solution, labeled with the concentration and date, washed at the tap to remove any solution that might cling to the base of the cuttings, and immediately set in the propagation bench. They were thoroughly watered as soon as planted, after which water was applied as needed. Some difficulty was encountered in maintaining the proper moisture relationships for the many different species all close together in the same bench. This was not serious in the case of easily and quickly rooted species; but for those that rooted with difficulty, or stayed long in the bench, it doubtless contributed to occasional failures.

DATA

The effectiveness of the treatments was determined from observations which included: 1. The length of time required for the development of a satisfactory root system for transplanting purposes, 2. the excellence of the root system as determined by number, size, vigor and location of roots, 3. the absence of abnormal reactions such as excessive splitting and swelling of the stem, killing of the base of the cutting, checking of shoot growth and loss of foliage.

As the cuttings were dug they were graded on an arbitrary numerical basis, 100 for very good roots, 75 for good, 50 for fair, 25 for poor and 0 for dead and unrooted cuttings. The highest ranking was given to cuttings having several well-developed roots arising close to the base. Grading was done by sorting all the cuttings of a given species from any single series of tests into their respective classes, treatment by treatment, and then recording the number of cuttings falling into each category and computing the average grade of the lot.

The observations were summarized and are presented in four tables: 1, dealing with reactions of herbaceous cuttings; 3, dealing with reactions of greenwood cuttings; 5, dealing with reactions of evergreen cuttings; 7, dealing with reactions of hardwood cuttings. The treatment which produced the best root systems in each series is indicated by underlining the average grade of that series. For more convenient reference the various species in each group, except the hardwoods, are listed under the concentration to which each gave the best response, tables 2, 4 and 6.

Many photographs were made, the subjects being selected carefully to illustrate the typical responses of various species to the treatments. The material was particularly well adapted to picture records. The plates included in this bulletin should be studied as carefully as the text, because they were chosen for the accuracy with which they represent the results of the experiments. Professional propagators will find them valuable for comparison with their own work, especially if they are experimenting with growth substances.

HERBACEOUS CUTTINGS

It will be seen from table 1 that herbaceous cuttings, almost without exception, responded favorably to treatment at one or more of the concentrations unless old, woody tissue was used or decay had attacked them. The optimum concentration for herbaceous cuttings ranged between 2.5 and 10 B. T. I. units. Table 2 lists the species responding most favorably to each concentration.

Responses to variation in concentration of Hormodin A varied unfavorably from the optimum in either direction. Higher than optimum concentrations were toxic, and lower concentrations were ineffective. Herbaceous cuttings treated with high concentrations of Hormodin A showed injury in the twisting and bending of stem and leaf-petioles, in the swelling and splitting of the stem caused by the formation of dense masses of short, underdeveloped roots and in the death of the base of the cutting. Concentrations higher than 20 units were usually injurious to herbaceous and succulent greenwood cuttings. A typical case of injury at high concentrations is seen in *Iresene herbstii,* (fig. 5). *Chrysanthemum hortorum* (fig. 6) and *Fuchsia speciosa* (fig. 7) also show the injury attending overtreatment. Injury was seldom permanent, however, for even the iresene cuttings treated with 80 units slowly recovered and grew into normal plants.

GREENWOOD CUTTINGS

The rooting response of greenwood cuttings of many species of deciduous trees and shrubs was variable. Failures due to faulty growing technique sometimes occurred. Two Iowa summers of wide and sudden fluctuations in temperature and generally low humidity were unfavorable for rooting greenwood cuttings even in the lath house. When the humidity was raised by watering or enclosing the frames, the combination of high humidity and high temperature led to loss of foliage and rotting of the cuttings. Some species, notably apple, failed with monotonous regularity regardless of the treatment. Compared with untreated cuttings, however, greenwood cuttings generally responded favorably to Hormodin A.

Table 3 shows that the spread of effective concentrations for greenwood cuttings was wide, ranging from 1.25 to 80 units. Only a few species, however, withstood treatments stronger than 40 units without injury. Greenwood cuttings when treated with too high concentrations were more severely injured than herbaceous cuttings. The leaves turned yellow and fell; only a little callus formed, and the base of the cutting blackened, then died; roots appeared far up on the stem in such numbers that the cutting could not support them; and further growth of bud, stem and root was checked.

The more leafy, succulent type of greenwood cutting suffered less permanent injury from overtreatment than the firmer wooded cuttings. *Buddleia asiatica* (fig. 8) and *Acalypha wilkesiana* (fig. 9), for example, although injured by overtreatment recovered soon after potting. Less succulent types, like *Rosa indica odorata* (fig. 10), *Lonicera japonica* (fig. 11), *Lonicera standishi, Lantana camara,* and *Syringa vulgaris* (fig. 12), lost their leaves shortly after potting, became dormant and seldom recovered. The ability of such cuttings to recover from the injury was correlated with vigorous growth.

Table 4 lists the species according to their optimum response to the several concentrations.

EVERGREEN CUTTINGS

Evergreen cuttings presented numerous problems in techniques not presented by herbaceous and greenwood cuttings. Generally slow to root, they sometimes rotted or died in the propagation bench before roots were initiated. Many cuttings made in the summer died either because the high temperatures were unfavorable or because the material was not at the right stage when the cuttings were made. Cuttings used during the winter of 1937-38, which had to be taken from short, stunted shoots, reacted less favorably, both with reference to injury and rooting, than cuttings made the following year. Treated cuttings were more damaged by high temperatures and fluctuations in moisture in the rooting medium than were untreated cuttings. Apparently they were also less resistant to decay. Frequently untreated cuttings, though failing to root, lived several weeks or even months after treated cuttings had died. Nevertheless, as will be seen by a study of table 5, when material, temperatures and moisture were properly controlled, evergreen cuttings responded favorably to Hormodin A. Slow-rooting species commonly propagated by cuttings, including *Buxus sempervirens* (fig. 31), *Juniperus squamata* (figs. 29, 30), *Taxus media hicksi* (fig. 27) and *Thuja occidentalis* were greatly benefited by the treatment.

Evergreens ordinarily difficult to root, which responded to treatment, included *Picea excelsa, Abies concolor, Juniperus chinensis* and varieties, and *Pinus mughus. Picea excelsa* (figs. 38, 39, 40) showed good rooting at 20 B. T. I. units, but as it required a comparatively long time for rooting, it was difficult to maintain satisfactory conditions in the propagating medium, and many cuttings rotted before roots had time to form. *Juniperus chinensis* and its varieties behaved somewhat erratically. Eighty units, which induced formation of large root systems, were often injurious to the base of the cuttings; consequently 40 units, though less stimulating to rootage, are recommended because of the higher percentage of survivals. Possibly the erratic responses of *Juniperus communis* were allied with dormancy and the age of the cutting wood. *Pinus mughus* rooted well at 80 units but was subject to rotting in the cutting bed.

The concentration required for evergreen cuttings was higher than for herbaceous and greenwood cuttings, most of the species falling between 20 and 80 B. T. I. units. Cuttings of evergreens varied in their response, depending upon the species, time of year, age of tissue and concentration employed. *Thuja, Chamaecyparis, Juniperus communis* varieties and *Juniperus horizontalis* were injured by treatments higher than 40 units. *Picea excelsa* and *P. pungens* cuttings were damaged by 40 units, while *Pinus mughus* was not injured by the highest concentration (80 units). Table 6 lists the species responding most favorably to each concentration; species responding about equally well to more than one concentration are listed under each.

Coniferous evergreen cuttings taken at intervals from October to April, except *Juniperus communis depressa* and *Juniperus communis pfitzeriana,* rooted with approximately equal celerity and excellence under the same optimum concentration of Hormodin A, regardless of the exact date of taking. Cuttings of *Juniperus communis depressa* when taken in October and February rooted best at a concentration of 40 units, but when taken in April they rooted best at 20 units. Cuttings of Pfitzer's juniper, on the other hand, responded better to a high concentration in April (80 units) than earlier in the winter (November and January) when 40 units gave the best rooting.

The data do not justify any attempt to state a certain time of year is best for the taking and treating of cuttings of the more difficult species. *Taxus cuspidata brevifolia* cuttings taken in summer rooted best at 40 units, while those taken in winter rooted best at 80 units. This is the only case which agrees with Kiplinger's findings on Pfitzer's juniper (8).

Coniferous evergreen cuttings varied in their behavior in different media. *Arborvitae, Chamaecyparis* and *Taxus* rooted better in a medium holding more moisture than the coarse sand. Root growth was more vigorous in sand and peat mixtures for all the conifers than in coarse sand, but the percentage of cuttings rooting was generally lower.

HARDWOOD CUTTINGS

Hardwood cuttings from many plants were treated and planted in the greenhouse bench in 1938. Apple, pear, black raspberry, red oak, black walnut, barberry, black haw, *Forsythia* species, *Rosa* species, and others were treated unsuccessfully both before and after callusing. In fact, treated cuttings were more often damaged by the treatment than helped. Frequently the base of the cutting would swell and form peculiar enlargements about the buds; cushions of spongy callus would appear underneath the bark which would finally split as a baked apple splits its skin; buds would be checked in growth and large lenticels would form. The symptoms of injury corresponded to those described by Wallace for hardwood apple cuttings treated with ethylene (24).

In general the results with hardwood cuttings were unfavorable. A limited number of cuttings of peach, *Philadelphus coronarius* and the grape variety "Lucile" rooted, indicating that further experiments, possibly involving improvements in technique, might lead to a higher percentage of success in rooting this type of cutting. Table 7 presents the data for treatments of hardwood cuttings.

An interesting experiment on the importance of a callus in rooting hardwood cuttings was performed on peach. Eighty peach cuttings callused at the base were taken from storage April 20, 1938. The calluses were removed from half the cuttings and retained on the other half. Each group was then divided equally and treated with growth substance, one-half with the tops of the cuttings immersed in the solution, the other half with the bases immersed. No roots formed on cuttings from which the calluses were removed, regardless of the end immersed; 23 percent of the callused cuttings which were basally treated rooted. It is concluded, therefore, that the formation of callus tissue is necessary for rootage of peach cuttings, the observations adding weight to the correctness of the common practice of callusing hardwood cuttings of many species before "sticking" them in the propagating beds.

RECOMMENDATIONS

The experiments described in this bulletin show that the rooting of herbaceous, greenwood and evergreen cuttings of many species of horticultural plants was hastened, a larger percentage of cuttings was successfully rooted and raised and the size of the roots was increased by the use of Hormodin A. Cuttings treated with optimum concentrations made vigorous, normal plants when potted or transplanted to nursery rows.

The cost of treatment varied with the concentration required for individual species. At retail prices Hormodin A will treat from 500 to 1,000 herbaceous, greenwood or evergreen cuttings at a cost varying from $1, when purchased in very small quantities, to 35 cents in larger amounts.

Propagators are advised to use growth substance under the following circumstances:

1. Only with plants which have responded favorably to experimental treatments as reported in tables 8 and 9.
2. Where propagation space is limited and rapid succession of plantings is economically desirable.
3. When, for any special reason, extra speedy rooting is desired.
4. With species which, though rootable, are rooted only with considerable difficulty when untreated.

Propagators are emphatically cautioned to follow directions closely, especially with reference to concentration and length of time of treatment. The quantity of growth substance necessary to stimulate rooting is so much less than the average user's imagination can picture that there is the greatest temptation to use too much. Table 8 shows the concentrations found most effective in the experiments above reported. Especially important for successful treatment with growth substances are optimum environmental conditions. Treated cuttings are more sensitive to unfavorable temperature and moisture than untreated cuttings. The great majority of treated herbaceous, greenwood and evergreen cuttings would root best if soil temperatures could be maintained constantly within a range of 65° to 70° F., with air temperatures approximately 10° lower. Recognizing the practical difficulties involved in maintaining these conditions, the propagator nevertheless is advised to come as near to furnishing these temperatures as possible. The humidity requirements naturally vary somewhat with species, but percentages generally should be high and should be kept under control by maintaining as even an air temperature as possible, thus preventing condensation with falling temperatures and drying out with rising temperatures, and by such devices as syringing the foliage, dampening the soil under the benches and the walks, and covering cuttings with cheesecloth.

TABLE 1. ROOTING RESPONSE OF HERBACEOUS CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration								Remarks †
					80	40	20	10	5	2.5	1.25	Ck	
Ageratum houstonianum	15	2- 4-38	17	F.S.				90	88	75	51	26	See fig. 55
Antirrhinum majus	10	11-24-37	31	F.S.P.				95	57	67		47	
Antirrhinum majus	10	1- 9-38	16	F.S.			15	52	37			5	20 injured
Antirrhinum majus	10	2-24-38	36	C.S.			87	72	80			22	20 and 10 injured
Antirrhinum majus	10	3-30-38	23	C.S.			100	95	65			62	
Antirrhinum majus (27 hr. period)	10	4-16-38	19	C.S.			85	65	57			10	20 injured
Begonia semperflorens	28	1-25-38	49	F.S.					40	18		15	
Begonia semperflorens	50	2-16-38	27	F.S.					27	23		27	
Centaurea gymnocarpa	10	10- 9-38	24	C.S.				22	27	50		7	Old tissue
Cerastium tomentosa	10	11- 7-37	22	F.S.P.		62	70	67	52			12	40 and 20 injured
Chrysanthemum hortorum	10	11-26-37	12	F.S.P.				92	97	77		22	10 injured
Chrysanthemum hortorum	20	12- 6-37	18	F.S.P.				91	83	83		51	
Chrysanthemum hortorum Gold Lode	13	1-23-38	16	F.S.P.					84	86		51	
Chrysanthemum hortorum Dr. Enguehardt	10	1-23-38	16	F.S.P.					87	77		27	
Chrysanthemum hortorum Annabelle	10	1-23-38	16	F.S.P.					55	35		55	Diseased
Chrysanthemum hortorum	11	3- 4-38	21	C.S.			68	90	90	90		40	20 and 10 injured. See fig. 6
Chrysanthemum hortorum Cora Peck Buehl	15	5- 5-38	16	C.S.				73	85	83		73	10 injured
Chrysanthemum hortorum Gold Lode	8	5- 5-38	16	C.S.				75	70	75		62	10 injured
Chrysanthemum hortorum Legal Tender	8	5- 5-38	16	C.S.				28	15	72		6	10 injured
Chrysanthemum frutescens	10	12- 9-37	15	F.S.P.				97	92	90		27	

TABLE 1. ROOTING RESPONSE OF HERBACEOUS CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS—Continued

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration								Remarks †
					80	40	20	10	5	2.5	1.25	Ck	
Chrysanthemum frutescens	15	2- 6-38	15	F.S.P.				90	71	66	62	48	
Dianthus caryophyllus	10	12- 3-37	21	F.S.P.		82	92	90	92			32	
Dianthus caryophyllus	10	2-19-38	23	C.S.		85	82	47	62			22	
Dianthus caryophyllus	10	3-19-38	30	C.S.			97	82	70			57	
Dianthus caryophyllus	10	10-11-38	42	C.S.			30	45	42			37	
Dianthus caryophyllus	10	10-18-38	19	C.S.			60	37	15			30	Mature tissue
Dianthus caryophyllus	10	11-11-38	11	C.S.			82	60	32			10	Soft tissue
Dianthus caryophyllus	15	1- 9-39	16	F.S.				48				0	
Dianthus caryophyllus	10	4- 2-39	22	F.S.			72	57	52			7	20 injured
Eupatorium riparium	10	5- 3-38	16	C.S.			82	47	87			85	20 and 10 injured
Fuchsia speciosa (26 hrs)	10	2-27-38	16	C.S.			80	80	82	72		2	See fig. 7.
Fuchsia speciosa	10	3-27-38	23	C.S.				75	55	32		5	
Fuchsia speciosa	10	1-21-39	33	F.S.			27	95	87			5	20 and 10 injured
Iresene herbstii	10	12- 9-37	25	F.S.P.				97	100	97		72	
Iresene herbstii	10	2- 6-38	30	F.S.				70	72			65	Leafless cuttings
Ireseno herbstii	10	2- 6-38	30	F.S.				52	62			20	Internodal cuttings
Iresene herbstii (20 hr.)	20	2-16-38	18	F.S.P.	67	92	95	90	92	97	67	90	80, 40 and 20 injured. See fig. 5.
Lathyrus latifolius	10	11- 7-37	59	F.S.				12	0	15		20	Damped off
Linum flavum	10	10-29-38	24	C.S.			5	5	0			7	Old tissue
Medicago sativa	10	11-13-37	31	F.S.		40	60	72	64	82		12	
Medicago sativa	10	11-13-37	31	F.S.		45	41	72	31	62		37	
Mesembryanthemum roseum	10	2-18-38	25	F.S.			80	80	82			67	Soft tissue
Mesembryanthemum roseum	10	2-18-38	25	F.S.			90	95	95			80	Mature tissue
Monarda didyma	10	10-11-38	22	C.S.			32	10	0	17		2	20 injured: old tissue

TABLE 1. ROOTING RESPONSE OF HERBACEOUS CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS—Continued

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration: 80	40	20	10	5	2.5	1.25	Ck	Remarks †
Monarda didyma	10	10-29-38	24	C.S.			80	50	35			22	Terminal soft tissue
Pelargonium hortorum	5	2-25-38	18	C.S.			85	80	45			15	See fig. 1
Pelargonium hortorum	10	12- 8-38	24	F.S.				40	70	77		65	Rot at base
Pelargonium hortorum Missouri	8	6-15-38	22	C.S.				93	71			0	Basal rot
Pelargonium hortorum S. A. Nutt.	10	6-15-38	22	C.S.				57	75			2	
Pelargonium hortorum Riccard	8	6-15-38	22	C.S.				62	62			12	
Pelargonium hortorum Mrs. Waters	13	6-15-38	22	C.S.			42	94	94			5	20 injured
Pelargonium hortorum Mt. Mort	10	6-15-38	22	C.S.				72				15	
Pelargonium hortorum Mrs. Beach	10	6-15-38	22	C.S.			77	60	80			2	
Pelargonium hortorum	10	10- 9-38	24	C.S.			30	7	55			15	Basal rot
Pelargonium domesticum	10	2-27-38	33	C.S.				62	27	25		10	20 injured
Pelargonium domesticum	15	6-24-38	26	C.S.			45	58	36	40		25	
Pelargonium peltatum	10	2-27-38	16	C.S.				100	80	80		15	See fig. 15.
Pelargonium peltatum	10	6-16-38	22	C.S.			62	80	62			30	
Pelargonium tricolor	10	1-26-38	41	F.S.				62	80	87		22	
Pelargonium tricolor (26 hr.)	10	2-27-38	33	C.S.				57	57	25		2	
Penstemon barbatus	10	10-11-38	26	C.S.			20	40	20			0	Diseased
Penstemon barbatus	10	10-11-38	25	C.S.			45	65	50			2	
Petunia hybrida	10	4- 3-38	19	C.S.				72	45	40		45	
Phlox paniculata	10	10- 9-38	24	C.S.			75	45	52	25		49	
Piqueria trinervia	15	3-31-38	22	C.S.		60	86	93					40 and 20 injured
Piqueria trinervia	10	5- 3-38	16	C.S.			62	60	90			57	20 and 10 injured
Pilea microphylla	10	1-21-39	33	F.S.				70	67	47		42	10 injured
Senecio mikanioides	10	1-26-38	27	F.S.				77	85	57		67	
Senecio mikanioides	10	1- 9-39	16	F.S.				82	80	95		45	
Senecio cineraria	10	1-26-38	26	F.S.				60	30	42		35	
Senecio cineraria	10	10-16-38	17	C.S.			60	37	45			12	20 injured

TABLE 1. ROOTING RESPONSE OF HERBACEOUS CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS—Continued

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration								Remarks †
					80	40	20	10	5	2.5	1.25	Ck	
Telanthera versicolor	10	10–9–38	18	C.S.				72	95	$\underline{97}$		80	
Verbena erinoides	10	10–29–38	15	C.S.			70	$\underline{80}$	77			37	
Verbena hybrida	10	10–9–38	7	C.S.			22	22	$\underline{32}$			0	
Verbena hybrida	10	10–28–38	8	C.S.			52	76	$\underline{65}$			5	
Verbena venosa	7	10–29–38	15	C.S.			89	85	$\underline{89}$			32	
Veronica longifolia subsessilis	10	10–30–38	23	C.S.			$\underline{60}$	32	15	2		2	Old tissue
Euphorbia pulcherrima	15	1–29–38	35	F.S.		53	33	35				30	40 and 20 injured. See figs. 44, 45.
Euphorbia pulcherrima	20	6–15–38	22	C.S.		73	$\underline{70}$	51	42			23	See figs. 16, 17. Mature wood
					40	30	20	15	10	5		Ck	
Euphorbia pulcherrima	20	6–21–38	21	C.S.	12	47	30	$\underline{51}$	28	35		33	

*F.S.—Fine sand.
F.S.P.—Fine sand and peat mixture.
C.S.—Coarse sand.
†Number given refers to B. T. I. concentration causing injury.
NOTE: Underline indicates treatment considered best by the authors.

TABLE 2. OPTIMUM CONCENTRATIONS OF HORMODIN A FOR CUTTINGS OF HERBACEOUS SPECIES

B. T. I. Units			
2.5	5	10	20
Centaurea gymnocarpa	*Antirrhinum majus*	*Ageratum houstonianum*	*Monarda didyma*
Chrysanthemum hortorum	*Begonia semperflorens*	*Antirrhinum majus*	*Dianthus caryophyllus*
Chrysanthemum frutescens	*Chrysanthemum hortorum*	*Cerastium tomentosum*	*Veronica longifolia subsessilis*
Iresene herbstii	*Chrysanthemum frutescens*	*Dianthus caryophyllus*	
Medicago sativa	*Eupatorium riparium*	*Pelargonium species*	
Senecio mikanioides	*Fuchsia speciosa*	*Penstemon barbatus*	
Telanthera versicolor	*Iresene herbstii*	*Petunia hybrida*	
	Mesembryanthemum roseum	*Fuchsia speciosa*	
	Phlox paniculata	*Medicago sativa*	
	Pelargonium species	*Piqeuria trinerva*	
	Piqueria trinerva	*Senecio cineraria*	
	Pilea microphylla	*Verbena erinoides*	
	Senecio mikanioides	*Euphorbia pulcherrima*	
	Verbena hybrida		
	Verbena venosa		

TABLE 3. ROOTING RESPONSE OF GREENWOOD CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration								Remarks †
					80	40	20	10	5	2.5	1.25	Ck	
Acalypha hispida	10	4- 1-38	20	C.S.		70	35	42				7	40 and 20 injured
Acalypha hispida wilkesiana marginata	10	4- 1-38	21	C.S.		55	77	95				47	40 and 20 injured. See fig. 9.
Allamanda cathartica	10	2- 4-38	55	C.S.		87	72	70	37			47	
Allamanda cathartica	10	11- 6-38	48	C.S.		50	65	25				2	
Ampelopsis tricuspidata	10	7-30-38	42	C.S.P.	27	30	42					5	Large calluses
Berberis thunbergi	10	10-14-38	29	C.S.		5	27	12				0	Old tissue
Berberis thunbergi	10	10-29-38	24	C.S.		30	10	30				5	Old tissue
Buddleia asiatica	20	3-31-38	21	C.S.			45	38	73	62		36	20 and 10 injured. See fig. 8.

TABLE 3. ROOTING RESPONSE OF GREENWOOD CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS—Continued

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration								Remarks †
					80	40	20	10	5	2.5	1.25	Ck	
Buddleia asiatica	15	5- 3-38	18	C.S.				58	70	80		46	10 injured
Buddleia davidi	10	10-30-38	14	C.S.				67	57	27	30	2	Mature material
Buddleia davidi	5	10-30-38	14	C.S.						60	60	15	Soft material
Bougainvillea glabra	10	11- 6-38	48	C.S.		55	62	35	42			7	40 injured
Callicarpa japonica	10	10- 9-38	24	C.S.		60	65	30				10	40 injured. See figs. 47, 48.
Caragana frutex	10	11-10-38	56	F.S.	0	10	62	55				45	
Caryopteris incana	10	4-29-38	33	S.P.			97	72	72	77		70	
Caryopteris incana	10	10- 9-38	18	C.S.				60	52	0		7	
Ceanothus ovatus	10	10- 9-38	44	C.S.		30	20	37				5	
Cissus rhombifolia	10	2-27-38	32	C.S.			70	90	35			10	40 and 20 injured
Clematis paniculata	10	7-28-38	28	C.S.		27	80	75				3	40 and 20 injured
Clematis paniculata	10	10-18-38	45	C.S.		88	60	20				5	40 injured
Clerodendron thompsonae	15	2-16-38	43	C.S.		72	72	63				53	
Clerodendron thompsonae	10	11- 6-38	48	C.S.		50	60	40				42	
Codiaeum variegatum (26 hr.)	10	2-27-38	32	C.S.		35	60	37				3	See fig. 2.
Cotoneaster soongarica	10	10-17-38	36	C.S.	0	3	0					0	
Cytisus canariensis	10	12-15-37	45	C.S.		50	52	32	17			0	40 injured
Cytisus canariensis	15	3-27-38	66	C.S.		65	48	57				47	
Deutzia scabra watereri	10	10- 9-38	24	C.S.			53	38	30			5	20 injured
Deutzia Pride of Rochester	10	10-14-38	39	C.S.				90	78	78		85	
Deutzia laxifolia	10	10-14-38	71	C.S.				73	58	90		80	
Deutzia scabra pleniflora	10	11- 4-38	39	C.S.			55	45	50			55	
Diervilla trifida	10	10-30-38	23	C.S.			50	28	25			10	
Eleagnus angustifolia	10	10-18-38	35	C.S.		20	0	0				0	
Euonymus japonicus	10	3-30-38	22	C.S.		78	70	43				0	40 and 20 injured. See fig. 56.

TABLE 3. ROOTING RESPONSE OF GREENWOOD CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS—Continued

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration								Remarks †
					80	40	20	10	5	2.5	1.25	Ck	
Euphorbia splendens	10	3-30-38	35	C.S.		48	50	48				23	See figs. 53, 54.
Forsythia intermedia spectabilis	10	10-9-38	24	C.S.			63	70	35			45	
Forsythia intermedia primulina	8	10-14-38	23	C.S.			60	45	15			20	
Forsythia intermedia primulina	10	10-30-38	66	C.S.			65	77	45			30	See figs. 21, 22, 23, 24.
Fontanesia fortunei	10	10-30-38	64	F.S.	40	45	53	5				0	
Gardenia veitchi	15	3-26-38	30	C.S.			18	18	23			0	
Hibiscus rosa-sinensis	10	1-23-39	40	C.S.		48	35	20				28	40 injured
Hibiscus rosa-sinensis	8	3-14-38	32	C.S.		41	9	6				0	
Hydrangea opuloides	10	6-24-38	26	C.S.		68	60	73				25	40 and 20 injured
Kolkwitzia amabilis	10	10-30-38	66	F.S.		8	3	0				0	
Lantana camara	10	12-8-37	24	F.S.P.		75	60	62	67	36		6	40 and 20 injured
Lantana camara	13	1-6-38	29	F.S.			64	52	13			0	20 injured. See fig. 41.
Lantana camara	10	2-7-38	25	C.S.			85	82	57			62	No injury
Lantana camara	10	10-16-38	19	C.S.			68	50	50			5	20 injured
Lantana camara	10	1-21-39	33	F.S.			12	25	77			22	20 and 10 injured
Lantana sellowiana	10	12-8-37	24	F.S.P.		85	82	92	42			26	40 and 20 injured
Lantana sellowiana	10	2-7-38	25	C.S.			95	90	80			75	20 injured
Lantana sellowiana	10	2-7-38	25	C.S.			92	72	55			72	20 and 10 injured
Lantana sellowiana	10	2-7-38	25	C.S.			50	12	30			5	20 injured
Lantana sellowiana	10	10-16-38	17	C.S.			52	45	47			2	20 injured
Ligustrum amurense	15	7-28-38	28	C.S.	67	27	28					30	Mature wood
Ligustrum amurense	10	10-15-38	45	C.S.	83	83	78					65	Soft tips. See figs. 32, 33.
Ligustrum regelianum	10	11-10-37	42	F.S.P.	75	42	27	0				0	
Ligustrum regelianum	10	10-9-38	44	C.S.	17	12	2					0	

TABLE 3. ROOTING RESPONSE OF GREENWOOD CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS—Continued

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration: 80	40	20	10	5	2.5	1.25	Ck	Remarks †
Ligustrum vulgare foliosa	9	10- 9-38	44	C.S.	36	22	0					0	
Ligustrum vulgare Lowdense	10	11- 8-37	44	F.S.P.	75	40	25					7	
Ligustrum vulgare Lowdense	10	10-18-38	67	C.S.	17	80	15					25	
Lonicera bella albida	10	11-12-37	42	F.S.P.	0	0	0	0				22	80 to 10 injured
Lonicera bella albida	10	10-13-38	33	C.S.				12	67	67		0	10 and 5 injured. See figs. 18, 19, 20.
Lonicera japonica articulata	10	1-26-38	44	F.S.			57	45	72	77			20 and 10 injured. See figs. 11, 51.
Lonicera japonica articulata	10	1-21-39	33	F.S.				80	75	70	32	2	10 injured
Lonicera standishi	10	10-15-38	70	C.S.					27	32	27	17	
Malus sylvestris—root sprouts	10	11- 7-37	29	F.S.P.	2	15	30					0	80 and 40 injured
Nerium oleander	10	1-23-38	40	F.S.		8	60	38				38	40 injured
Nerium oleander	10	3-14-39	32	C.S.		45	40	40				3	
Philadelphus coronarius	15	10-30-38	66	F.S.			87	63	67			47	
Philadelphus Virginal	5	10-30-38	66	F.S.			95	60	40			15	
Pyracantha coccinea gibbsi	10	10-17-38	36	C.S.	25	40	18					35	
Potentilla fruticosa	10	10-30-38	66	C.S.			43	40	35			23	20 injured
Rosa indica odorata	10	11-23-37	20	F.S.P.			0	38	3	25		0	20 and 10 injured
Rosa indica odorata	10	11-23-37	20	F.S.P.			60	60	48	40		15	20 and 10 injured
Rosa indica odorata	10	11-23-37	41	F.S.P.				10	33	25		55	
Rosa indica odorata	5	11-23-37	31	F.S.P.				20	85	65		0	
Rosa indica odorata	20	2- 1-38	33	C.S.				25	31	45		19	See fig. 10.
Rosa indica odorata Briarcliff	10	11-12-37	31	F.S.		0	0	10	48			35	
Rosa indica odorata Briarcliff	10	4- 1-38	33	C.S.				20	38	35		13	10 injured
Rosa manetti	10	3-27-38	23	C.S.				63	60	43		15	See fig. 28.

TABLE 3. ROOTING RESPONSE OF GREENWOOD CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS—Continued

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration								Remarks †
					80	40	20	10	5	2.5	1.25	Ck	
Rosa multiflora	10	3-29-38	21	C.S.				53	83	53		35	See fig. 34.
Rosa multiflora x R. blanda	10	10-16-38	21	C.S.				38	38	20		0	
Rosa multiflora Excelsa	10	4-23-38	40	C.S.	30	45	42					30	
Rosa multiflora Climbing America Beauty	10	10-19-38	66	C.S.				5	13	25		13	
Rosa multiflora Chenaults	10	10-14-38	71	C.S.				3	8	20		20	
Rosa multiflora Dorothy Perkins	10	10-14-38	23	C.S.				80	60	63		43	
Rosa multiflora Tausend schoen	10	10-18-38	26	C.S.				28	5	18		0	
Rosa polyantha Kluis' Scarlet	8	4- 2-38	32	C.S.					97	53		19	See fig. 46.
Syringa vulgaris Chas. Joly	10	5- 1-38	66	C.S.	58	10	10					0	80 injured. See fig. 12.
Spiraea billardi	8	10-14-38	30	C.S.		28	72	66				16	20 injured
Spiraea arguta	10	10-17-38	36	C.S.			68	63	30			8	20 injured
Spiraea bumaldi	10	10-30-38	66	C.S.			83	65	65			13	20 injured

*F.S.—Fine sand.
F.S.P.—Fine sand and peat mixture.
C.S.—Coarse sand.
C.S.P.—Coarse sand and peat mixture.
†Number given refers to B. T. I. concentration causing injury.
NOTE: Underline indicates treatment considered best by the authors.

TABLE 4. OPTIMUM CONCENTRATIONS OF HORMODIN A FOR GREENWOOD CUTTINGS OF VARIOUS SPECIES

B. T. I. Units					
2.5	5	10	20	40	80
Buddleia asiatica *B. davidi* *Lonicera bella albida* *L. japonica articulata* *L. standishi* *Rosa indica odorata*	*Buddleia asiatica* *B. davidi* *Deutzia* species *Gardenia veitchi* *L. japonica articulata* *Rosa indica odorata* *Rosa multiflora* and hybrids *Rosa polyantha* *Spiraea bumaldi*	*Acalypha hispida* *A. wilkesiana marginata* *Berberis thunbergi* *Caryopteris incana* *Ceanathus ovatus* *Cissus rhombifolia* *Clematis paniculata* *Cytissus canariensis* *Deutzia* species *Euonymus japonicus* *Forsythia* species *Hydrangea opuloides* *Lantana camara* *L. sellowiana* *Nerium oleander* *Potentilla fruiticosa* *Rosa manetti* *R. multiflora Excelsa* *Spiraea billardi* *S. arguta*	*Allamanda cathartica* *Ampelopsis tricuspidata* *Berberis thunbergi* *Bougainvillea glabra* *Callicarpa japonica* *Caragana frutex* *Caryopteris incana* *Clematis paniculata* *Clerodendron thompsonae* *Codiaeum variegatum* *Cytissus canariensis* *Diervilla trifida* *Euphorbia splendens* *Forsythia* species *Fontanesia fortunei* *Hibiscus rosa-sinensis* *Malus sylvestris* (root sprouts) *Nerium oleander* *Philadelphus coronarius*	*Eleagnus angustifolia* *Hibiscus rosa-sinensis* *Ligustrum amurense* *L. vulgare lowdense* *Pyracantha coccinea gibbsi*	*Ligustrum amurense* *L. regelianum* *L. vulgare foliosa* *L. vulgare lowdense* *Syringa vulgaris*

TABLE 5. ROOTING RESPONSE OF EVERGREEN CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration								Remarks †
					80	40	20	10	5	2.5	1.25	Ck	
Abies concolor	20	1-23-38	60	C.S.	17	7	0					0	
Buxus sempervirens	10	3-27-38	68	C.S.	70	40	8					5	
Buxus sempervirens	20	1-23-38	57	C.S.	70	50	16					4	See fig. 31.
Chamaecyparis pisifera plumosa	10	1-22-39	39	C.S.	23	48	8					13	
Chamaecyparis pisifera plumosa	5	11- 8-38	74	F.S.P.	30	45	30					35	
Chamaecyparis pisifera plumosa	10	4-16-38	82	C.S.	23	60	43					43	See fig. 13.
Chamaecyparis pisifera plumosa	10	10-30-38	70	C.S.	5	10	10					5	
Juniperus chinensis	10	10-10-38	143	C.S.	35	25	28					0	
Juniperus chinensis pfitzeriana	10	2- 4-38	152	C.S.		30	5	13				0	
Juniperus chinensis pfitzeriana	10	4-16-38	147	C.S.	55	20	20					8	
Juniperus chinensis pfitzeriana	10	4-16-38	147	C.S.P.	70	60	35					33	
Juniperus chinensis pfitzeriana	10	11- 4-38	120	C.S.	8	38	23					3	
Juniperus chinensis pfitzeriana	10	1- 7-39	97	C.S.	10	28	8					0	
Juniperus chinensis pfitzeriana	10	1- 8-39	96	C.S.	15	35	3					5	
Juniperus chinensis pfitzeriana	10	1- 8-39	72	C.S.	45	5	0					0	
Juniperus chinensis pyramidalis	10	10-10-38	182	C.S.	18	33	10					18	80 injured
Juniperus chinensis pyramidalis	10	10-10-38	182	C.S.	0	10	30					15	80 and 40 injured
Juniperus communis depressa	10	10-10-38	92	C.S.	0	20	5					18	
Juniperus communis depressa	10	2- 4-38	182	C.S.		75	68	40				30	See fig. 25.
Juniperus communis depressa	10	4-14-38	83	C.S.	18	15	43					15	
Juniperus communis depressa	10	4-14-38	83	C.S.P.	25	20	33					10	
Juniperus communis depressa plumosa	10	4-14-38	149	C.S.	15	15	35					8	
Juniperus communis depressa plumosa	10	10- 9-38	93	C.S.	3	35	0					0	
Juniperus communis depressa plumosa	10	1- 9-39	94	C.S.	10	5	0					8	

TABLE 5. ROOTING RESPONSE OF EVERGREEN CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS—Continued

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration								Remarks †
					80	40	20	10	5	2.5	1.25	Ck	
Juniperus communis depressa plumosa	10	10- 9-38	144	C.S.	15	45	3					13	
Juniperus procumbens	10	4-15-38	154	C.S.	18	8	0					0	
Juniperus sabina	10	1- 8-39	53	C.S.	0	10	0					0	
Juniperus sabina horizontalis "gray form"	10	10-10-38	143	C.S.	0	0	0					8	
Juniperus sabina horizontalis "green form"	10	11- 4-38	118	C.S.	35	60	27					8	
Juniperus squamata wilsoni	10	1-21-39	82	C.S.	20	20	8					0	See figs. 36, 37.
Juniperus squamata var.	10	1-21-39	82	C.S.	43	35	8					0	See figs. 29, 30.
Picea excelsa	10	11-11-38	111	C.S.	5	10	33					15	
Picea excelsa	10	11-11-38	111	C.S.	0	0	40					20	See figs. 38, 39, 40.
Picea pungens	10	1- 9-39	84	C.S.	8	5	0					8	
Pinus mughus	10	4-16-38	81	C.S.	10	8	28					0	
Pinus mughus	10	11-16-38	99	C.S.	13								
Pinus mughus	10	1-21-39	40	C.S.	33	0	0					0	See fig. 35.
Pinus mughus	10	1-21-39	42	C.S.	28	0	0					0	
Taxus cuspidata brevifolia	10	4-16-38	81	C.S.	30	25	48					45	
Taxus cuspidata brevifolia	10	11-16-38	106	C.S.	50	65	40					0	
Taxus media hicksi	10	3- 5-38	77	C.S.	83	63	83	43				48	
Taxus media hicksi	10	3- 5-38	77	C.S.	83	50	3	10				3	
Taxus media hicksi	10	4-14-38	109	C.S.	83	58	43					20	See fig. 27.
Taxus media hicksi	10	4-14-38	109	C.S.P.	78	48	33					10	
Teucrium chamaedrys	20	1-21-38	46	F.S.		80	63	80				30	See fig. 26.
Teucrium chamaedrys	10	3-27-38	25	C.S.	30	50	33					0	
Teucrium chamaedrys	10	10- 9-38	44	C.S.	68	35	13					0	

TABLE 5. ROOTING RESPONSE OF EVERGREEN CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS—Continued

Name of plant	No. of cuttings per lot	Date made	Days in medium	Rooting medium (*)	Average grade of each lot treated with each concentration: 80	40	20	10	5	2.5	1.25	Ck	Remarks †
Teucrium chamaedrys	10	1–31–39	33	F.S.	100	50	55					0	
Thuja occidentalis	50	1–21–39	42	C.S.	20	26	3					1	In flats
Thuja occidentalis	50	1–21–39			0	3	10						In bench
Thuja occidentalis	10	1–29–38	183	C.S.	55	80	30					18	80 injured
Thuja occidentalis	10	1–29–38	73	F.S.P.	35	40	5					3	80 injured
Thuja occidentalis	10	1–29–38	73	F.S.	38	63	10					5	80 injured
Thuja occidentalis	10	1–29–38	182	F.S.P.	60	55	0					8	
Thuja occidentalis	10	10–10–38	31	C.S.		68	3					25	
Thuja occidentalis	10	10–10–38	92	C.S.		18	10					28	
Thuja occidentalis	10	10–30–38	123	C.S.	8	35	0					5	80 injured
Thuja occidentalis wareana	20	12–17–37	116	F.S.P.	29	53	28					8	80 injured. See fig. 52.
Thuja occidentalis wareana	10	3– 8–38	134	C.S.		13	20	0	3			0	80 injured
Thuja occidentalis wareana	10	10–30–38	123	C.S.	33	58	25					18	80 injured
Thuja occidentalis var.	10	1– 8–39	95	C.S.	75	35	25					38	80 injured
Thuja occidentalis var.	10	12–14–38	52	F.S.P.	15	8	8					0	80 injured

*F.S.—Fine sand.
F.S.P.—Fine sand and peat mixture.
C.S.—Coarse sand.
C.S.P.—Coarse sand and peat mixture.
†Number given refers to B. T. I. concentration causing injury.
NOTE: Underline indicates treatment considered best by the authors.

TABLE 6. OPTIMUM CONCENTRATIONS OF HORMODIN A FOR CUTTINGS OF EVERGREEN SPECIES

B. T. I. Units		
20	40	80
Juniperus chinensis pyramidalis	*Chamaecyparis pisifera plumosa*	*Abies concolor*
J. communis depressa	*Juniperus chinensis pfitzeriana*	*Buxus sempervirens*
J. communis depressa plumosa	*J. chinensis pyramidalis*	*Chamaecyparis pisifera plumosa*
Picea excelsa	*J. communis depressa*	*Juniperus chinensis*
Taxus cuspidata brevifolia	*J. communis depressa plumosa*	*J. chinensis pfitzeriana*
Thuja occidentalis wareana	*J. sabina*	*J. procumbens*
	J. sabina horizontalis "green form"	*J. squamata*
	J. squamata wilsoni	*Pinus mughus*
	Taxus cuspidata brevifolia	*Taxus media hicksi*
	Teucrium chamaedrys	*Teucrium chamaedrys*
	Thuja occidentalis	
	T. occidentalis wareana	

TABLE 7. THE ROOTING RESPONSE OF HARDWOOD CUTTINGS TREATED WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS

Name of plant	No. of cuttings	Date treated	Days in medium	Concentration	No. of cuttings rated as: Good	Poor	Not rooted
Amygdalus persica	10	4-20-38	42	80	1	2	7
Callused cuttings				40	1	1	8
Base treated				20	1	1	8
				Ck	0	0	10
Amygdalus persica							
Callused cuttings	10	4-20-38	41	80	0	2	8
Top treated				40	0	0	10
				20	0	1	9
				Ck	0	0	10
Philadelphus coronarius							
Callused cuttings	10	6- 3-38	29	80	6	4	0
				40	0	0	10
				20	0	8	2
				Ck	0	0	10
Vitis labrusca—Lucile							
Base treated	10	5-30-38	33	160	8	2	0*
Callused cuttings				80	7	2	1
				40	8	1	1
				20	5	5	0
				10	3	4	3
				Ck	3	4	3
Vitis labrusca—Lucile	10	5-30-38	33	160	7	3	0
Tops treated				80	2	5	3
Buds damaged				40	4	3	3
Callused cuttings				20	4	2	4
				Ck	4	5	1

*See figs. 42, 43.
NOTE: All cuttings were rooted in the fine sand.
The data on the uncallused *Amygdalus* cuttings are omitted. All failed to root, though treated as were the callused cuttings.

TABLE 8. RECOMMENDATIONS FOR TREATMENT OF CUTTINGS WITH DIFFERENT CONCENTRATIONS OF HORMODIN A FOR A PERIOD OF 24 HOURS

Name of plant	Type of cutting	Hormodin A B. T. I. Units
Antirrhinum majus	Herbaceous	10
Begonia semperflorens	Herbaceous	5
Chrysanthemum hortorum	Herbaceous	2.5
Chrysanthemum frutescens	Herbaceous	5–2.5
Dianthus caryophyllus	Herbaceous	10
Fuchsia speciosa	Herbaceous	5
Iresene herbstii	Herbaceous	5
Mesembryanthemum roseum	Herbaceous	5
Monarda didyma	Herbaceous	20
Pelargonium hortorum	Herbaceous	5
P. domesticum	Herbaceous	10
P. peltatum	Herbaceous	10
P. tricolor	Herbaceous	5–2.5
Penstemon barbatus	Herbaceous	10
Piqueria trinervia	Herbaceous	5
Senecia mikanioides	Herbaceous	5–2.5
S. cineraria	Herbaceous	10–5
Verbena hybrida	Herbaceous	5
Euphorbia pulcherrima	Herbaceous	20–15
Allamanda cathartica	Greenwood	20
Berberis thunbergi	Greenwood	20–10
Buddleia asiatica	Greenwood	5–2.5
B. davidi	Greenwood	5–2.5
Caryopteris incana	Greenwood	20–10
Clematis paniculata	Greenwood	20–10
Clerodendron thompsonae	Greenwood	20
Deutzia species	Greenwood	5
Forsythia species	Greenwood	10
Hibiscus rosa-sinensis	Greenwood	20
Lantana camara	Greenwood	10
Lantana sellowiana	Greenwood	10–5
Ligustrum species	Greenwood	80
Lonicera species	Greenwood	2.5
Nerium oleander	Greenwood	20–10
Philadelphus coronarius	Greenwood	20
Rosa indica odorata	Greenwood	5–2.5
Rosa multiflora	Greenwood	10–5
Buxus sempervirens	Evergreen	80–40
Chamaecyparis pisifera plumosa	Evergreen	40
Juniperus chinensis	Evergreen	80
Juniperus chinensis pfitzeriana	Evergreen	40
Juniperus chinensis pyramidalis	Evergreen	80–40
Juniperus communis depressa	Evergreen	40–20
J. communis depressa plumosa	Evergreen	40–20
Picea excelsa	Evergreen	20
Pinus mughus	Evergreen	80
Taxus cuspidata brevifolia	Evergreen	40
Taxus media hicksi	Evergreen	80–40
Teucrium chamaedrys	Evergreen	80–40
Thuja occidentalis	Evergreen	40
Thuja occidentalis varieties	Evergreen	40

TABLE 9. LIST OF DIFFICULT PLANTS REPORTED BENEFITED BY TREATMENT WITH HORMODIN A, OR INDOLEBUTYRIC ACID

Name of Plant	Reference
Acer rufinerve limbatum	Tincker (21)
Azalea calendulacea	Yerkes (29)
Azalea indica	Watkins (26)
Azalea japonica	Yerkes (29)
Azalea mollis	Yerkes (29)
Camellia japonica alba plena	Watkins (26)
Camellia sasanqua	Watkins (26)
Carya pecan	Stoutemyer (18)
Chimonanthus fragrans (Meratia praecox)	Tincker (21)
Cornus florida	Kiplinger (8) Yerkes (29)
Cornus florida rubrum	Kiplinger (8)
Ginkgo biloba	Kiplinger (8)
Ilex crenata	Hitchcock & Zimmerman (6)
Ilex glabra	Kiplinger (8)
Ilex opaca	Hitchcock & Zimmerman (6)
Kalmia latifolia myrtifolia	Tincker (21)
Kolkwitzia amabilis	Kiplinger (8) Yerkes (29)
Lagerstroemia indica	Watkins (26)
Magnolia grandiflora	Watkins (26)
Magnolia kobus borealis	Yerkes (29)
Magnolia liliflora	Yerkes (29)
Malus var. *Eleyi*	Yerkes (29)
Pittosporum dalli	Tincker (21)
Podocarpus nagi	Watkins (25)
Polygonum paniculatum	Tincker (21)
Prunus triloba plena flore	Yerkes (29)
Robinia pseudoacacia rectissima	Stoutemyer (18)
Syringa emodi	Kirkpatrick (10)
Syringa henryi	Kirkpatrick (10)
Syringa josikaea	Kirkpatrick (10)
Syringa persica	Kirkpatrick (10)
Syringa tomentosa	Kirkpatrick (10)
Syringa villosa	Kirkpatrick (10)
Syringa vulgaris varieties	Kirkpatrick (10) Oliver (14)
Tsuga canadensis	Hitchcock & Zimmerman (6) Yerkes (29)
Vitis rotundifolia	Yerkes (29)

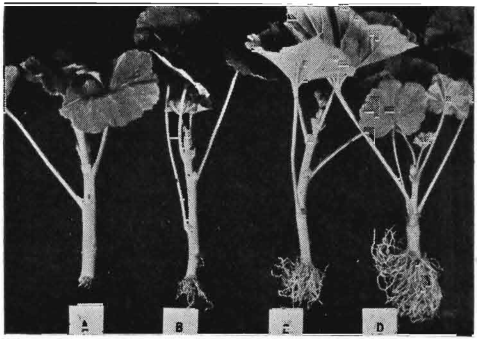


FIG. 1.
Pelargonium hortorum.

Treated 2-25-38.
Dug 3-15-38.
A—Check.
B— 5 B. T. I. Units.
C—10 B. T. I. Units.
D—20 B. T. I. Units.

FIG. 2.
Codiaeum variegatum.

Treated 26 hrs., 2-27-38.
Dug 4-1-38.
A—Check.
B—10 B. T. I. Units.
C—20 B. T. I. Units.
D—40 B. T. I. Units.

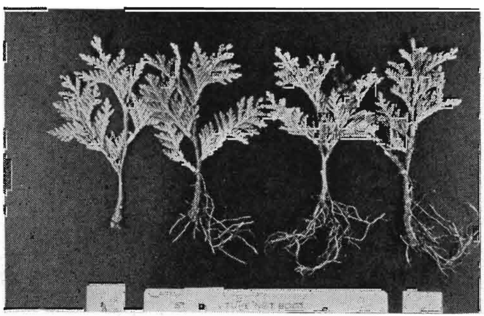


FIG. 3.
Thuja occidentalis wareana.

Treated 12-17-38.
Dug 4-12-38.
A—Check.
B—20 B. T. I. Unts.
C—40 B. T. I. Units.
D—80 B. T. I. Units.

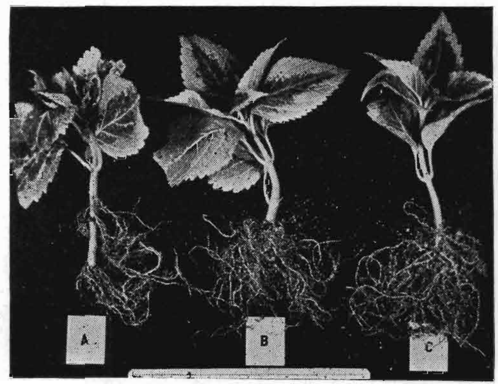


FIG. 4.
Coleus blumei.

Data not recorded.
A—Check.
B— 5 B. T. I. Units.
C—10 B. T. I. Units.

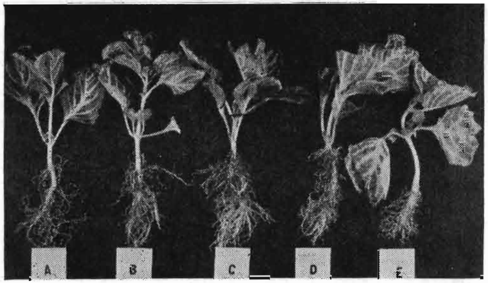


FIG. 5.
Iresene herbstii.
Treated 2-16-38.
Dug 3-6-38.
A—Check.
B— 2.5 B. T. I. Units.
C—10 B. T. I. Units.
D—20 B. T. I. Units.
E—80 B. T. I. Units.

FIG. 6.
Chrysanthemum hortorum.
Treated 3-4-38.
Dug 3-25-38.
A—Check.
B— 2.5 B. T. I. Units.
C— 5 B. T. I. Units.
D—10 B. T. I. Units.
E—20 B. T. I. Units.

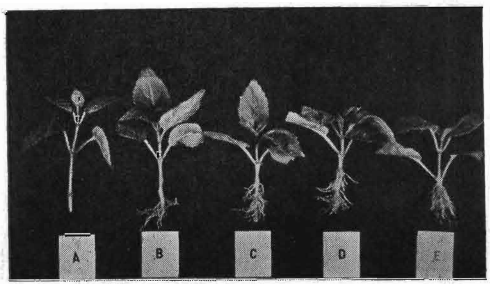


FIG. 7.
Fuchsia speciosa.
Treated 26 hrs., 2-27-38.
Dug 3-15-38.
A—Check.
B— 2.5 B. T. I. Units.
C— 5 B. T. I. Units.
D—10 B. T. I. Units.
E—20 B. T. I. Units.

FIG. 8.
Buddleia asiatica.
Treated 3-31-38.
Dug 4-21-38.
A—Check.
B— 2.5 B. T. I. Units.
C— 5 B. T. I. Units.
D—10 B. T. I. Units.
E—20 B. T. I. Units.

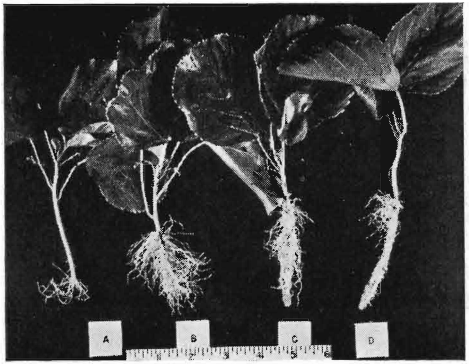


Fig. 9.
Acalypha wilkesiana marginata.

Treated 4-1-38.
Dug 4-22-38.
A—Check.
B— 2.5 B. T. I. Units.
C— 5 B. T. I. Units.
D—10 B. T. I. Units.

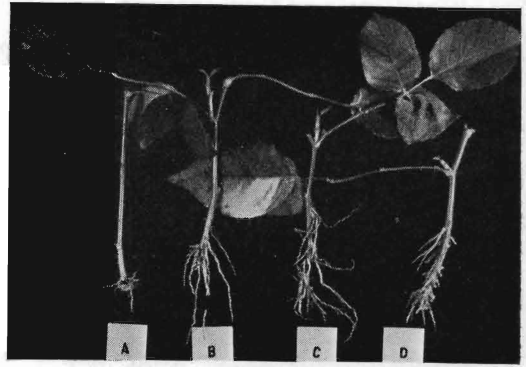


Fig. 10.
Rosa indica odorata.

Treated 2-1-38.
Dug 3-6-38.
A—Check.
B— 2.5 B. T. I. Units.
C— 5 B. T. I. Units.
D—10 B. T. I. Units.

Fig. 11.
Lonicera japonica articulata.

Treated 1-26-38.
Dug 3-11-38.
A—Check.
B— 2.5 B. T. I. Units.
C— 5 B. T. I. Units.
D—10 B. T. I. Units.
E—20 B. T. I. Units.

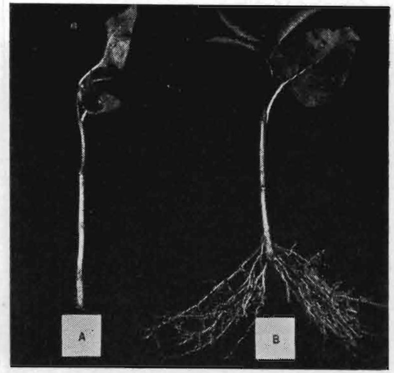


Fig. 12.
Syringa vulgaris, Charles Joly

Treated 5-1-38.
Dug 7-6-38.
A—Check.
B—80 B. T. I. Units.

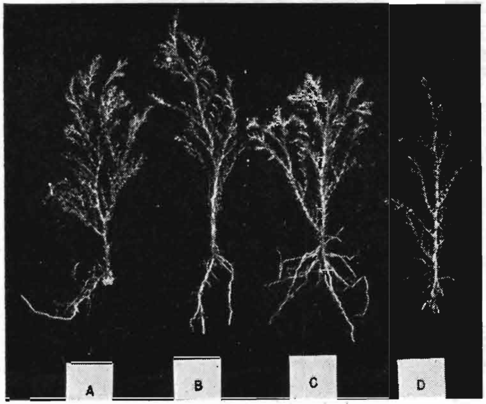


FIG. 13.
Chamaecyparis pisifera plumosa.

Treated 4-16-38.
Dug 7-3-38.
A—Check.
B—20 B. T. I. Units.
C—40 B. T. I. Units.
D—80 B. T. I. Units.

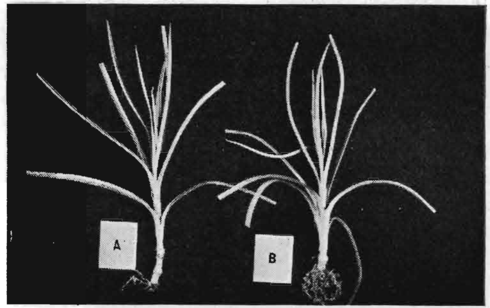


FIG. 14.
Dianthus caryophyllus.

Treated 1-20-38.
Dug 2-22-38.
A—Check.
B—10 B. T. I. Units.

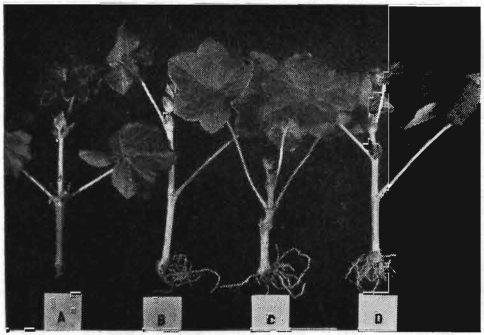


FIG. 15.
Pelargonium peltatum.

Treated 2-27-38.
Dug 3-15-38.
A—Check.
B— 2.5 B. T. I. Units.
C— 5 B. T. I. Units.
D—10 B. T. I. Units.

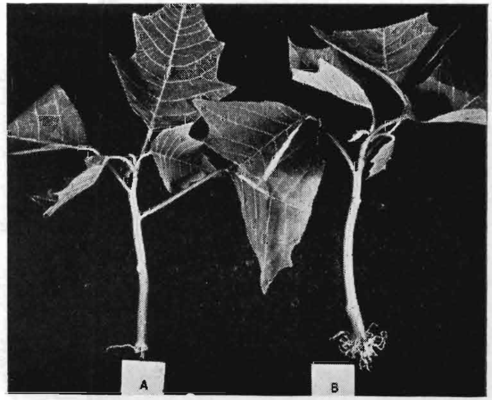


FIG. 16.
Euphorbia pulcherrima.

Treated 6-15-38.
Dug 7-7-38.
A—Check.
B—10 B. T. I. Units.

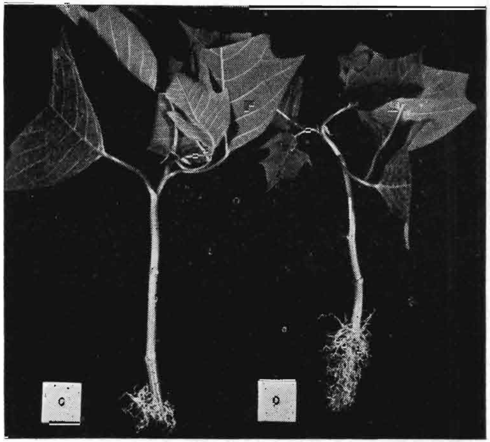


FIG. 17.
Euphorbia pulcherrima.

Treated 6-5-38.
Dug 7-7-38.
C—20 B. T. I. Units.
D—40 B. T. I. Units.

FIG. 18.
Lonicera bella albida.

Treated 10-13-38.
Dug 11-18-38.
A—Check.

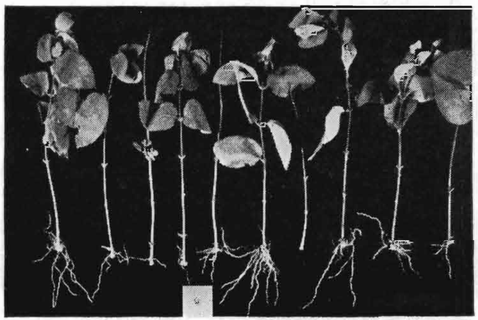
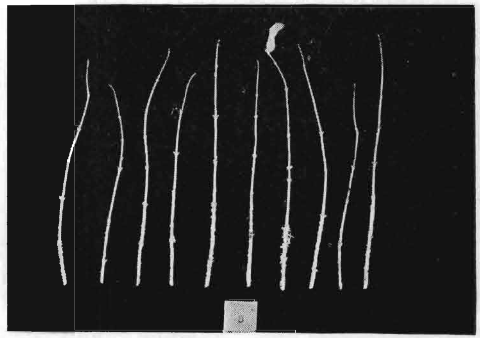


FIG. 19.
Lonicera bella albida.

Treated 10-13-38.
Dug 11-18-38.
C—2.5 B.T.I. Units.

FIG. 20.
Lonicera bella albida.

Treated 10-13-38.
Dug 11-18-38.
B—10 B. T. I. Units.



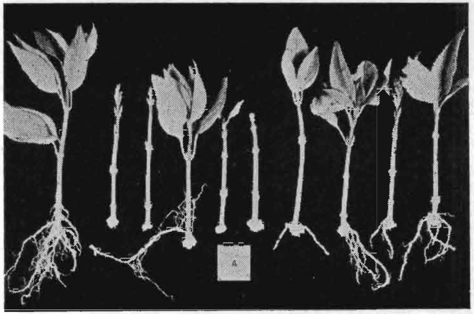


FIG. 21.
Forsythia intermedia primulina.

Treated 10-30-38.
Dug 1-4-39.
A—Check.

FIG. 22.
Forsythia intermedia primulina.

Treated 10-30-38.
Dug 1-4-39.
B—5 B. T. I. Units.

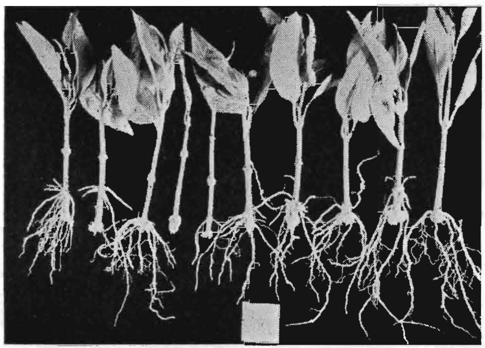


FIG. 23.
Forsythia intermedia primulina.

Treated 10-30-38.
Dug 1-4-39.
C—10 B. T. I. Units.

FIG. 24.
Forsythia intermedia primulina.

Treated 10-30-38.
Dug 1-4-39.
D—20 B. T. I. Units.

FIG. 25.
Juniperus communis depressa.

Treated 2-4-38.
Dug 7-5-38.
A—Check.
B—40 B. T. I. Units.

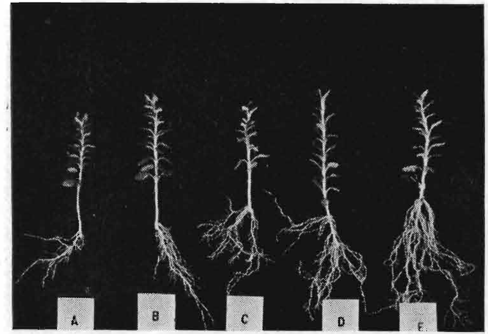


FIG. 26.
Teucrium chamaedrys.

Treated 1-21-38.
Dug 3-8-38.
A—Check.
B— 5 B. T. I. Units.
C—10 B. T. I. Units.
D—20 B. T. I. Units.
E—40 B. T. I. Units.

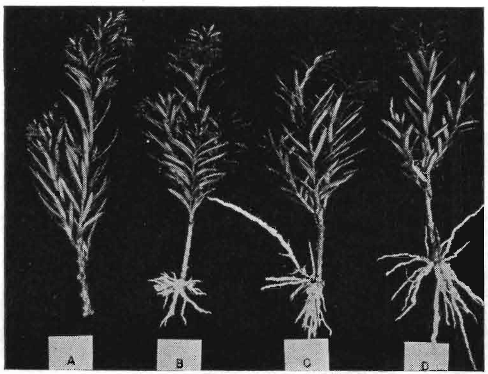


FIG. 27.
Taxus media hicksi.

Treated 4-14-38.
Dug 7-1-38.
A—Check.
B—20 B. T. I. Units.
C—40 B. T. I. Units.
D—80 B. T. I. Units.

FIG. 28.
Rosa manetti.

Treated 3-27-38.
Dug 4-19-38.
A—Check.
B— 2.5 B. T. I. Units.
C— 5 B. T. I. Units.
D—10 B. T. I. Units.

FIG. 29.
Juniperus squamata variety.

Treated 1-21-39.
Dug 4-13-39.
A—Check.

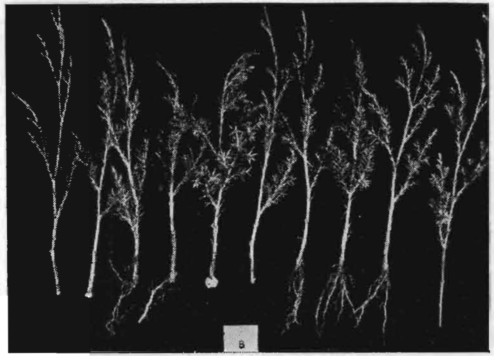


FIG. 30.
Juniperus squamata variety.

Treated 1-21-39.
Dug 4-13-39.
B—80 B. T. I. Units.

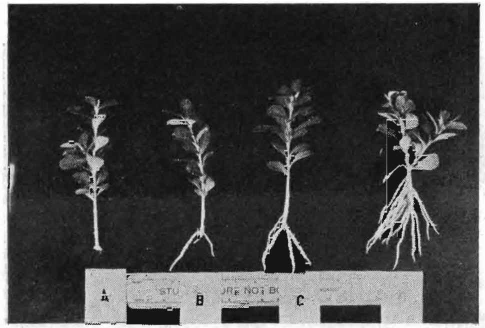


FIG. 31.
Buxus sempervirens.

Treated 1-23-38.
Dug 3-21-38.
A—Check.
B—20 B. T. I. Units.
C—40 B. T. I. Units.
D—80 B. T. I. Units.

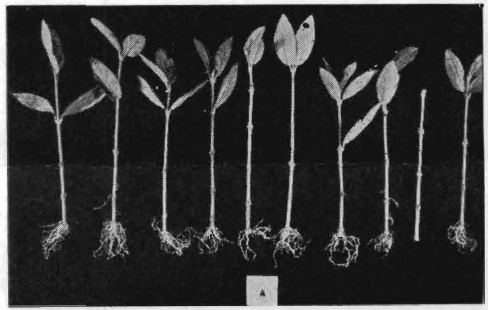


FIG. 32.
Ligustrum amurense.

Treated 10-15-38.
Dug 11-29-38.
A—Check.

FIG. 33.
Ligustrum amurense.

Treated 10-15-38.
Dug 11-29-38.
C—40 B. T. I. Units.

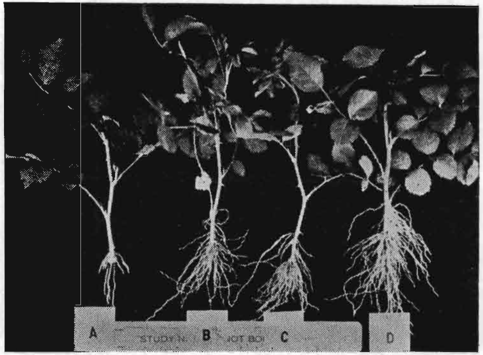


FIG. 34.
Rosa multiflora.

Treated 3-29-38.
Dug 4-19-38.
A—Check.
B— 2.5 B. T. I. Units.
C— 5 B. T. I. Units.
D—10 B. T. I. Units.

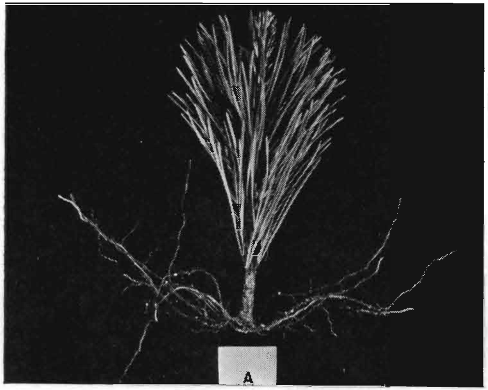


FIG. 35.
Pinus mughus.

Treated with Unit 80 1-21-39.
Photographed 4-13-39.
Controls all dead.

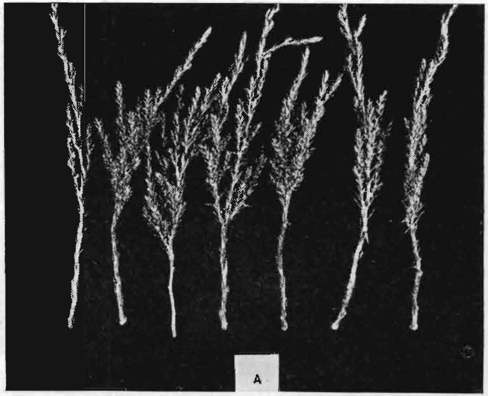


FIG. 36.
Juniperus squamata wilsoni.

Treated 1-21-39.
Dug 4-13-39.
A—Check.

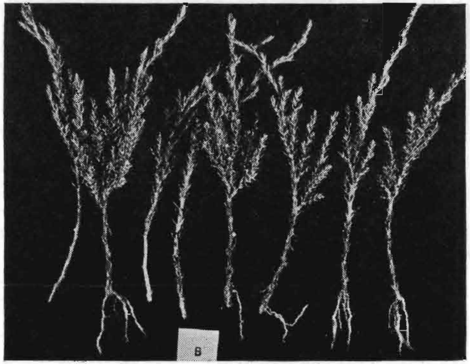


FIG. 37.
Juniperus squamata wilsoni.

Treated 1-21-39.
Dug 4-13-39.
B—Unit 40.

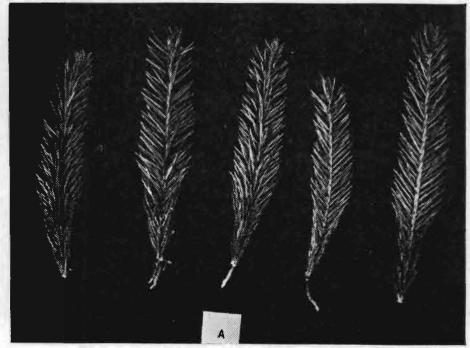


FIG. 38.
Picea excelsa.

Treated 11-11-38.
Dug 3-2-39.
A—Check.

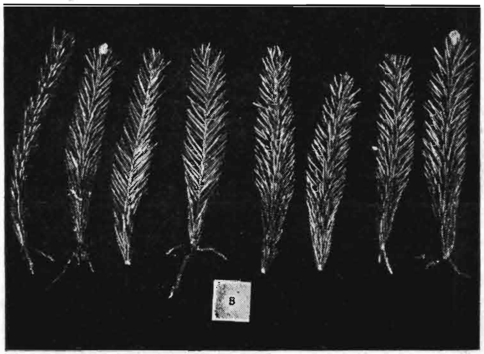


FIG. 39.
Picea excelsa.

Treated 11-11-38.
Dug 3-2-39.
B—20 B. T. I. Units.

FIG. 40.
Picea excelsa.

Treated 11-11-38.
Dug 3-2-39.
C—80 B. T. I. Units.

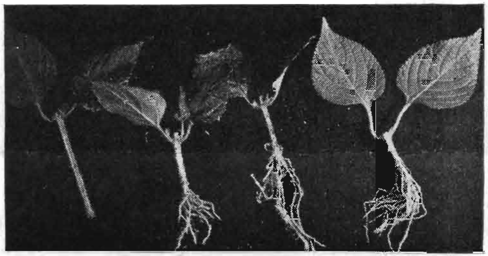


Fig. 41.
Lantana camara.

Treated 1-6-38.
Dug 2-4-38.
Left to right: Check, 5, 10, 20 B. T. I. Units.

Fig. 42.
Vitis labrusca Lucile.

Control lot. Treated with tap water 5-30-38 and dug after 33 days.

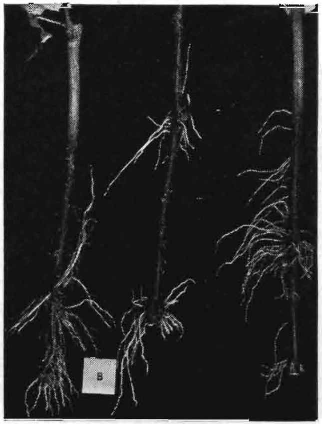


Fig. 43.
Vitis labrusca Lucile.

Treated at the base with Unit 160 on 5-30-38. Dug after 33 days.

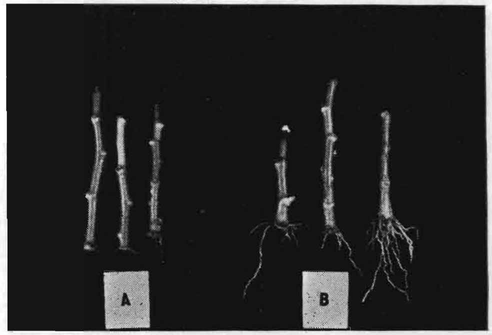


Fig. 44.
Euphorbia pulcherrima.

Treated 1-29-38.
Dug 3-5-38.
A—Check.
B—10 B. T. I. Units.

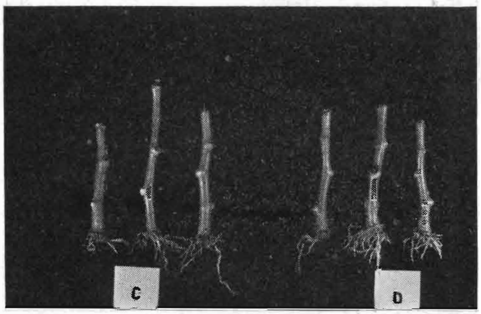


FIG. 45.
Euphorbia pulcherrima.

Treated 1-29-38.
Dug 3-5-38.
C—20 B. T. I. Units.
D—40 B. T. I. Units.

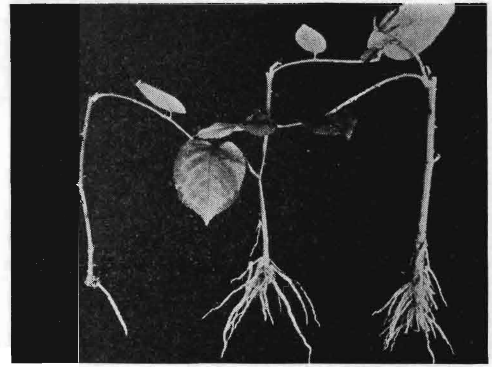


FIG. 46.
Rosa polyantha Kluis Scarlet.

Treated 4-2-38.
Dug 5-4-38.
Left to right: Check, 2.5, 5 B. T. I. Units.

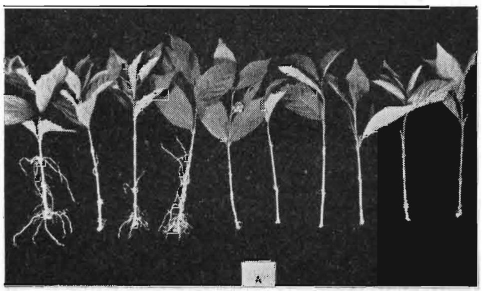


FIG. 47.
Callicarpa japonica.

Treated 10-9-38.
Dug 11-2-38.
A—Check.

FIG. 48.
Callicarpa japonica.

Treated 10-9-38.
Dug 11-9-38.
B—20 B. T. I. Units.

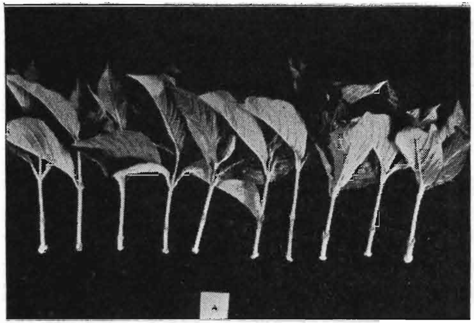


FIG. 49.
Weigela Isolene.

Treated 10-14-38.
Dug 11-9-38.
A—Check.

FIG. 50.
Weigela Isolene.
Treated 10-14-38.
Dug 11-9-38.
C—5 B. T. I. Units.

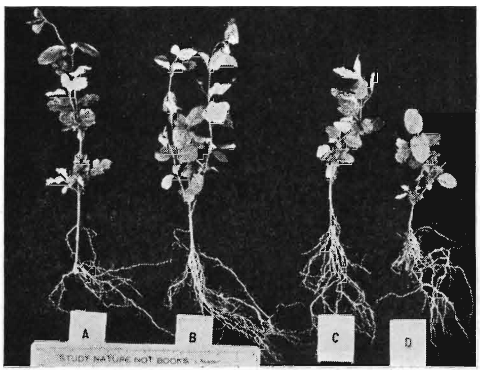


FIG. 51.
Lonicera japonica articulata.

Treated 1-26-38.
Dug 4-3-38. Note checking effect of high concentrations on shoot growth.
A—Check.
B— 2.5 B. T. I. Units.
C—10 B. T. I. Units.
D—20 B. T. I. Units.

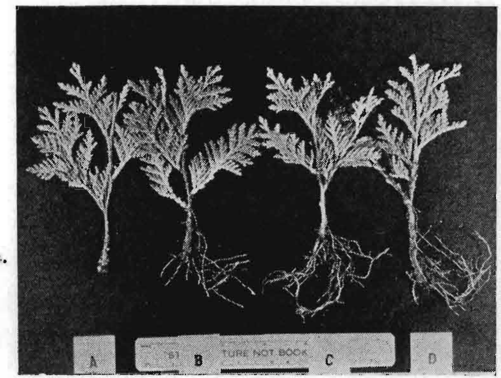


FIG. 52.
Thuja occidentalis wareana.

Treated 12-17-38.
Dug 4-12-38.
A—Check.
B—20 B. T. I. Units.
C—40 B. T. I. Units.
D—80 B. T. I. Units.

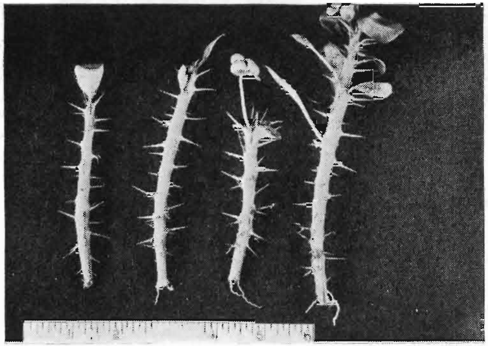


FIG. 53.
Euphorbia splendens.
Treated 3-30-38.
Dug 5-4-38.
Check.

FIG. 54.
Euphorbia splendens.

Treated 3-30-38.
Dug 5-4-38.
20 B. T. I. Units.

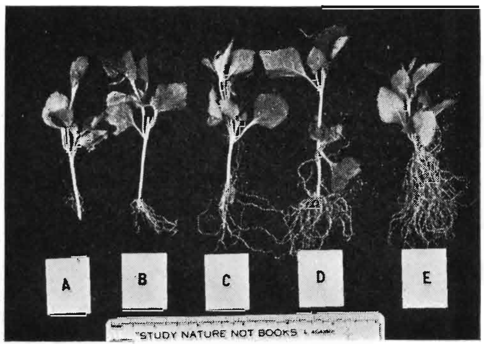


FIG. 55.
Ageratum houstonianum.

Treated 2-4-38.
Dug 2-21-38.
A—Check.
B— 1.25 B. T. I. Units.
C— 2.5 B. T. I. Units.
D— 5 B. T. I. Units.
E—10 B. T. I. Units.

FIG. 56.
Euonymus japonicus.

Treated 3-30-38.
Dug 4-21-38.
A—Check.
B—10 B. T. I. Units.
C—20 B. T. I. Units.
D—40 B. T. I. Units.

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